Morphologically the alimentary canal divided into three regions according to their method of embryonic origin :

1- <u>The foregut (stomodaeum)</u> : arises as an anterior ectodermal invagination .

Function of this region is :- store , grind and transport food to the next region .

The foregut include the :- buccal cavity , the pharynx , the esophagus , the crop (store food) and gizzard (grind foods) .

2- <u>Midgut</u> :- (mesenteron) : the midgut is where <u>digestion realy</u> happens , through enzymatic action .

Microscopic projection from the midgut wall , called microvilli , increase surface area and allow for maximum absorption .

Midgut , which ultimately connect the forgut with hindgut, develops in what is probably an <u>endodermal sac .</u>

Food is enveloped by this part of the gut as it arrives from the fore gut by the peritrophic <u>membrane</u> , secreted from the midguts epithelial cells .

The advantages of the peritrophic membrane are :-

a- Prevents food pathogens from contacting the insects body .
b- Acts as a filter allowing small molecules passing through , but preventing large molecules .

Usually between the foregut and mesentron is the esophageal or <u>cardiac valve</u> , and between the mesentron and the hindgut is the <u>pyloric valve</u>.

The midgut ultimately connect the fore and the hindgut , develops as what is probably an endodermal sac mesentron .

3- Hindgut (proctodeum) :- is as similar posterior invagination .

This is divided into three parts :-

a- Ileum is the anterior part .

b- The middle portion is the colon .

c- The posterior portion is the rectum which end in the anus .

So the fore and hindgut are lined with cuticle (intima)

The mesentron is not lined with cuticle , but with epithelium .

The intima (cuticle) is shed with every molt along with exoskeleton .

"Histology of foregut "

The foregut is ectodermal in origin .

The following layers passing from inside to the out :-

1- The intima.
2- Epithelial layer .
3- Basement membrane .
4- Longitudinal muscle layer.
5- Circular muscle layer .
6- Peritoneal membrane .

"The preoral cavity "

It is the space lying between the mouth parts and the labrum . this space in some insects is divided by the hypopharynx into :- a- Cibarium . b- Salivarium

In the Hemiptera the salivarium is modified into a salivary syring and in the Lepidoptera larvae into silk regulator .

Foregut is consist of following parts :-

1- **<u>Pharynx: -</u> is the first part of the foregut and has a series of dilator muscle in it for pushing the food to the esophagus.**
2- **<u>Esophagus</u>: - is undiffentiated part of the foregut, serving to pass food back from the pharynx to the crop ; provided with dilator muscle and its inner walls are longitudinally folded .**
3- **<u>Crop</u>: - it is an enlargement of the foregut in which the food is stored.**

No secretion, no absorption occure in the crop, why? But occur as a result of salivary, enzymes passing back although the gizzard acts as valve limiting the back ward movement of food, it does not prevent the regurgitation of the fluids.

4- **<u>Gizzard :-</u> the gizzard is variously modified in different insects .**
In fluid feeders it is absent except for a simple valve .
In the cockroach the intima in the gizzard is developed into six strong plates or teeth , which serve to break up the food by these teeth .
At the point of junction of the foregut and midgut , in many insect present the esophageal valve .

"Midgut"

The midgut does not have cuticular lining , but the majority of an insects it is lined by the delicate peritrophic membrane , internally it is lined by stratum of:-

1- <u>Interic epithelium</u> :- three main types of cell may be distinguish :-

a- Columnar cells

b- Regenerative cells

c- Calyciform . (goblet cell)

The columnar cells involved in the secretion of enzymes and the absorption.

The regenerative cell, may be as group of cell (nidi) and their function is to <u>renew</u> the other epithelia cells when these destroyed through secretion.

the goblet cells :- of uncertain function .

2- <u>Basement membrane .</u>

3- <u>Circular muscle</u>

4- <u>Longitudinal muscle</u>, an outer layer. note that the muscle layer position are the reverse to what obtain in the foregut

<u>The method of secretion may be :-</u>

1- Merocrine. 2- Holocrine. 3- Apocrine .

The surface area of midgut , in many insects are not only by microvilli , but also through of gastric caeca , a third method of achieving the same result is by the folding of the epithelial layer to form crypts.

"The Hindgut"

The first part of it is called ileum , the middle portion is the colon , and the wider , posterior portion is the rectum , which open exteriorly at the anus .

Histologically the hindgut lined by a layer of cuticle which is thinner and more permeable than that of the foregut and the circular muscle are presented both external and interior to the longitudeinal muscle layer.

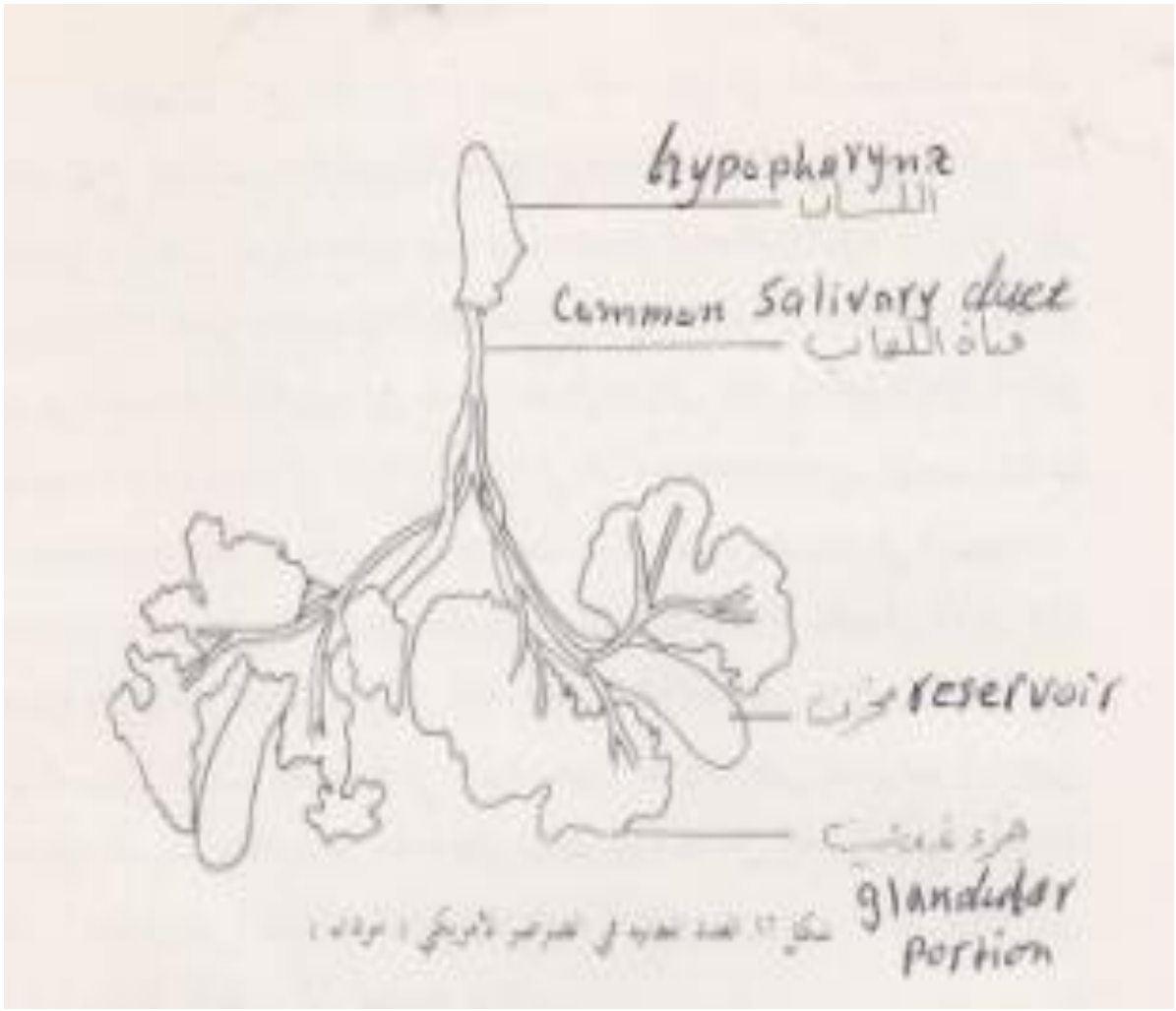
In many insects , the cellular layer of the rectum became thickened to form six longitudinal pads or rectal papilla .

Those are important in the absorpation of water , salts and amino acids from the contents of the rectum .

Malpighian tubules:- **They are long ,thin , bindly ending tubules arising from the gut near the junction of midgut and hindgut .they vary greatly in number .their function is excretion .**

The head gland associate with the mouth part are the mandibular , maxillary , pharyngeal and labial glands. although they are not usually all present together .

***The salivary gland*:-** **(labial gland) , this gland carry on a salivary function ,they are two in number ,laying ventral to the foregut in the head and thorax . they vary in size and shape but typically described as being acinar .**



The function of the saliva are :-

1- Lubricate the mouth part and moisten it .
2- Act as food solvent .
3- Contain enzymes which start the digestion .
4- Form silk in larva of Lepidoptera .
5- It use to glue puparial cases to the substrate .

The most common enzyme found in insect saliva are :- amylase and invertase , Sometimes protease and lipase. The saliva of some blood -sucking insects also contain <u>"antiogulant".</u>

"Digestion"

Digestion means the breaking down of micromolecules of the food into simpler soluble substances . the enzymes involved in this process .

The main group of enzymes have been found in insects:-

1- ***Carbohydrasese:-*** **which catalize the break down of complex carbohydrates to simple sugar . the amylase acts on starch while the glycosidase control to break down of the complex sugar .**
2- ***Lipases :-*** **which catalize the break down of fats .**
3- ***Proteases :-*** **which responsible for the digestion of protiens.**

The endopeptidases act on protein or peptones converting them to polypeptidases while the exopeptidases complete Digestion by the breaking down the peptidases into amino acid .

"Nutrition"

The basic Nutritional requirements for growth and development are known for only a few species . The necessary substances to synthetic diet are:-

1- ***Water :-*** **the insect can get water by :-**
   - **a- Absorption through the cuticle .**
   - **b- From metabolic source .**
   - **c- Take it from its food .**
   - **d- Take it directly.**

2- ***Mineral salts :-*** **that is including : k , p ,Mg , Na , Ca , Mn , Cu and Zn , which are required by insects in very small amount . Some insects, are able to absorb mineral ions from the water by their anal papillae .**

3- ***Carbohydrates :-*** **are not be essential nutritive substance for more insects , but they are probably the most common source of chemical energy utilized by insect , and need it in growth and development .**

4- ***Proteins and amino acids:-*** **amino acids are the building block of Proteins , and are required for building tissues , and enzymes usually presents as proteins . There are ten essential amino acids ; the absence of any one of it usually prevent growth .**

5- ***Vitamins:-*** **are required in very small amount . most insects don't need vitamins D , C ; but vitamin C is widely distributed in insect tissues indicating that it is synthesized , and vitamin A is not necessary for many insects , vitamin B complex are essential to most insects. It should be noted that many insects depend on microorganism for there supply or essential nutrients . In some cases that bacteria , fungi are found on the material on which the insect feed .**
In others the micro organism live in the gut , or they lodged in special organs (mycetomes) .

6- ***Purine and pyrimidine :-*** **The nucleic acid , DNA , RNA are composed of Purine and pyrimidine .**
RNA exert a positive effect on the growth of certain fly larvae .

"The Circulatory system"

It is comprises chiefly the blood and the organs which cause its circulation through the body .

The circulatory system of the insect , differ from that of the vertebrates in that it is open system and the blood inters the hemocoel . there is one blood vessels(dorsal blood vessel) .

The blood in the insect called hemolymph.

That means it carry on the functions of the blood and the lymph .

The characters of the hemolymph *:-*

1- **Colorless (sometimes it is colored) .**
2- **The concentration is 6-7 .**
3- **Denser than of the water .**
4- **Its Cl in less than that of the vertebrates .**
5- **With high concentration of amino acids .**

(the total molecular concentration in hemolymph is high) .

6- **Insect blood can be separated into two fractions :**
   a- **Fluid protein or plasma .**
   b- **Cellular protein or hemocytes .**

The plasma :- **which contain about 85 % waters , is usually slightly acid and include inorganic ions , amino acids , protein , fat , sugar , organic acids and other substances.**

Most of the carbohydrates is found in combination with protein , as glycogen . Several pigments have been identified in insect blood . among them are hemoglobin . both O_2 and CO_2 may occur.

Hemocytes :- **there are two categories of hemocytes :-**

1- **Phagocytic cells :- the principle function of the hemocytes in phagocytosis . The injestion of the solid particles , parasites , eggs and larvae of parasitoid . and they greatly increase in number during ecdysis and metamorphosis , these cells are including :-**

a- Granular leucocytes contain a large , central located nucleus , this type contains many inclusion , that love an acid stain and they have different shapes.

b- Proleucocytes :- small cell with deep staining cytoplasm and large nucleus ; often seen undergoing mitosis and are regarded as young form of hemocytes .

2- **Non-Phagocytic cells(oenocytoids):- so named from their resemblance to oenocytes ; large cell with rounded and spherical forms . incapable of Phagocytosis , having homogeneous cytoplasm strongly acidophile .**

In addition to these , other tissues are associated with the circulatory system :

1- Nephrocytes. 2- oenocytes .

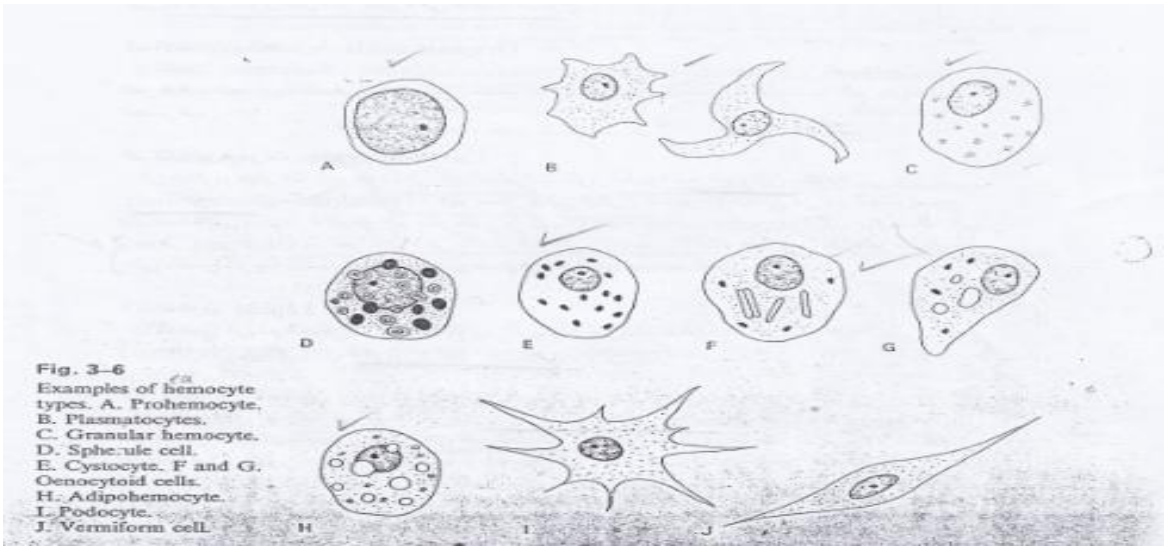


Fig. 3–6
Examples of hemocyte types. A. Prohemocyte. B. Plasmatocytes. C. Granular hemocyte. D. Spherule cell. E. Cystocyte. F and G. Oenocytoid cells. H. Adipohemocyte. I. Podocyte. J. Vermiform cell.